surrounding the vessel by a powerful magnetising helix," also obtained a negative result, perhaps for the same reason.

Knott's* experiments were made with hollow iron tubes, 45·7 cm. in length, 3·84 cm. in external diameter, and of different bores, ranging from 0·7 cm. to 3·19 cm. "Each tube was closed below, and into the upper end a nut screwed tightly, through a perforation in which issued a fine capillary glass tube. The nut was adjusted under water, so that the whole of the interior space of the metal tube was filled with liquid, and also part of the glass tube. When the tube was set vertically in the heart of the magnetising coil, the changes of volume were measured by the motions of the liquid meniscus in the capillary tube." "A few experiments were made on the external change of volume of a few of the tubes, which were enclosed in a thin-walled brass tube. The brass tube yielded because of its thinness, so that the results were not certain. But there was no doubt that with the specimens of iron tried there were large changes of volume."

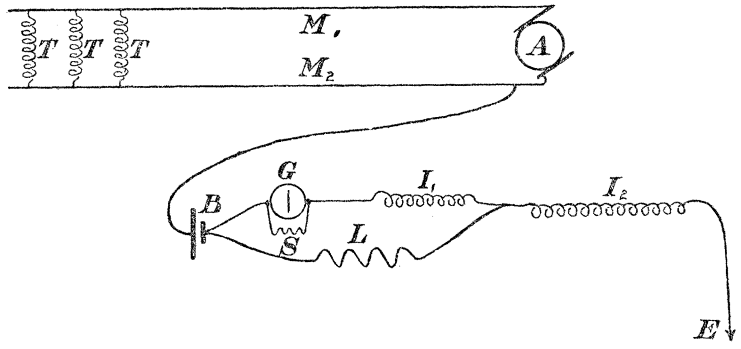
The changes observed by Knott in the interior volume appear in the case of a tube of large bore to have been of the same nature as those in my unannealed ring; while with a tube of smaller bore they rather resembled the changes exhibited by the annealed ring. His published investigations are, however, only of a preliminary character, and it is not at present possible to make a satisfactory comparison between his results and my own. But he was undoubtedly the first to show that magnetisation is generally attended by considerable changes of volume.

III. "Note on the Possibility of obtaining a Unidirectional Current to Earth from the Mains of an Alternating Current System." By Major P. CARDEW. Communicated by LORD KELVIN, P.R.S. Received May 10, 1894.

In carrying out some tests on the high-pressure alternating current system of the Metropolitan Electric Supply Company Ltd., of a combination intended to act as an indicator of leakage to earth, the existence under certain conditions of an excess of current in one direction to earth by leakage through the dielectric of the cables, or through small faults therein, has been demonstrated. The combinations and connexions used are shown in fig. 1, where A is the alternating current generator, M_1 and M_2 the distributing mains, TT the transformers, B a battery of a few Leclanché cells, G a

* 'Edin. Roy. Soc. Proc.,' 1891, p. 315; 1892, pp. 85, 249; 'Brit. Assoc. Rep.,' 1892, p. 659. The quotations are from the latter.

FIG. 1.



sensitive D'Arsonval reflecting galvanometer, S its $\frac{1}{9}$ shunt, I_1 and I_2 impedance coils, calculated to pass a current of less than 0·005 ampère with the whole alternating pressure in use on the system between the terminals, L a non-inductive resistance formed of four 50 C.P. 50-volt. incandescent lamps in parallel, E a connexion to the iron water-pipes supplying the station.

The object sought to be attained by the use of this arrangement was to obtain an indication of any leakage on the alternating system by a method which would be unaffected by the capacity effect of a large system.

It is intended to substitute for the D'Arsonval galvanometer used in these tests, a form of siphon recorder, so as to obtain a continuous record of leakage.

In the first tests, made on the 25th April, 1894, the mains in connexion consisted of eleven circuits all connected to one machine.

The pressure in the alternating circuit was rather greater than 1000 volts, and about half this pressure was indicated by an electrostatic voltmeter between M_2 and earth throughout the experiments.

The battery used was six cells, and the following deflections were obtained.

With $+^{ve}$ pole of battery to the mains ..	20 to left.
With $-^{ve}$ „ „ „ ..	140 to right.
With battery out of circuit	48 „

Various modifications were tried, but in all cases the results showed an apparent electromotive force of from 5 to 6 volts, tending to cause a flow of positive electricity to the water-pipe earth.

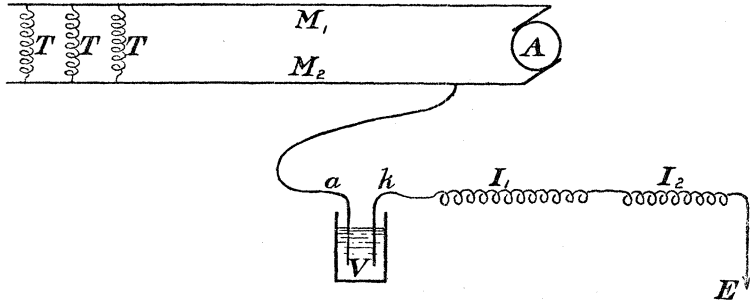
In order to settle this question, a small copper voltameter, consisting of two No. 40 S.W.G. copper wires in $CuSO_4$ solution, was inserted in place of the galvanometer and the shunts were removed.

In 2 hours and 10 minutes after connexion the wire connected to the mains was so far eaten through that it dropped off, while that connected to the water-pipe earth was visibly thickened by a deposit of copper. The gauge of the wires before and after this experiment was approximately as follows :—

Original gauge of each	0·005 inch.
Gauge of anode after experiment....	0·002 ,,
Ditto of kathode.....	0·0069 ,,

The connexions are shown in fig. 2, where V is the voltameter cell, *a* the wire which acted as anode, *k* that which acted as kathode.

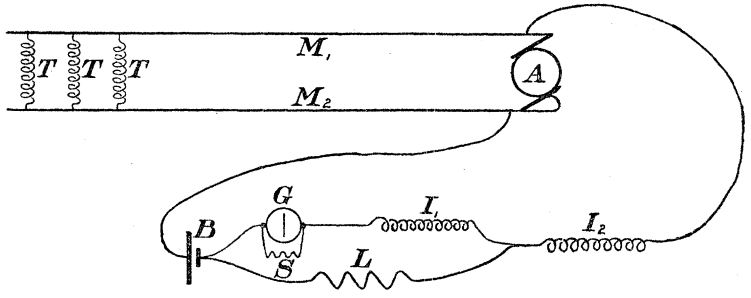
FIG. 2.



On the 2nd May, 1894, some further tests were taken.

In the first place a connexion to the opposite main was substituted for the connexion to the water-pipe, as shown in fig. 3.

FIG. 3.



This connection gave a deflection of about 235 to either side, according to the direction of the battery E.M.F., and absolutely no deflection without the battery.

On reverting to the connexions of fig. 1, a deflection of 130, gradually falling to 98 in 10 minutes, was obtained without any battery; and five Leclanché cells, connected $+^{ve}$ to mains, exactly reduced the deflection to zero.

The deflections obtainable with the connexions of fig. 1 without battery for varying lengths of street mains in connexion with the machine were then found to be as follows.

With the trunk main to Manchester Square Station alone, disconnected at the far end, no deflection was obtained:—

Adding No. 10 circuit, deflection of 15
„ No. 11 „ „ 25

(with a sudden rise to 70 and then a fall to 20).

Adding No. 12, no increase of deflection

(this is a small circuit for station lighting only).

Adding No. 7 circuit, deflection of 35
„ No. 6 „ „ 40
„ No. 5 „ „ 48
„ No. 4 „ „ 63
„ No. 3 „ „ 70
„ No. 2 „ „ 90
„ No. 1 „ „ 115

In all cases the first deflection was a few scale divisions greater than that after a few minutes.

The effect of an artificial leak of about 103,360 ohms resistance, consisting of a pencil of graphite mixed with clay or cement and connected to the water-pipes and to the main M_1, was then tried.

This produced no effect on the deflections without a battery, but slightly increased the deflection with a battery and with all mains connected.

When tried on the trunk main alone with the lamps removed, galvanometer unshunted and six Leclanché cells, the deflection was increased from about 23 to 360.

With seven Leclanché cells (say 10 volts) and the impedance coils and shunts as shown in fig. 1, a deflection of four scale divisions was produced when the circuit was completed through the resistance of 103,360 ohms in place of the mains and earth; this gives an indication of the sensibility of the arrangement.

The explanation of the results obtained appears to be that when the cables are charged with positive electricity the polarisation produced is sufficient during the time of one alternation to considerably increase the resistance of the slight leakage to earth by the formation, probably, of a film of oxides; this obstruction is cleared

off by the succeeding wave of negative charge, which, as is well understood, opens the leak. The time of an alternation is, however, quite insufficient to produce any such effect on the water-pipe earth, and, in consequence, the net result is a passage of negative electricity to earth through the cables, and of the corresponding positive quantity to earth by the water-pipes.

The maximum effect that has been observed so far amounts to an apparent E.M.F. slightly exceeding 10 volts, with the eleven circuits connected to one machine, but it appears that a greater effect would be produced by still further increasing the length of mains in connection.

IV. "The Effect of Mechanical Stress and of Magnetisation on the Physical Properties of Alloys of Iron and Nickel and of Manganese Steel." By HERBERT TOMLINSON, B.A., F.R.S. Received May 7, 1894.

(Abstract.)

The author has examined the principal physical properties of three alloys of nickel with iron and of the non-magnetic manganese steel of Mr. Hadfield, together with the effects of mechanical stress and magnetisation on these properties. The three nickel-iron alloys contain 22, 25, and 30 per cent. of nickel, and are designated Specimens D, E, and F respectively; they are in the form of thin wires, and similar specimens have been previously tested by Dr. John Hopkinson for the effect of change of temperature on their magnetic properties.* Specimen F practically loses its magnetic susceptibility at a temperature below 100° C., but regains it again on cooling to the temperature of the room. Specimens D and E are magnetic in the hard-drawn condition, but become non-magnetic when heated above 600° C. They do not, however, like Specimen F, regain their magnetic susceptibility when cooled to the ordinary temperature of the room, but can be made to do so, either by the process of wire-drawing, or by cooling them a few degrees below 0° C. Tables I and II contain the values of the principal physical constants of the three nickel-iron alloys, of Hadfield's non-magnetic manganese steel, and of nickel and iron. The former of these two tables relates to the substances in the hard-drawn condition in which they were received by the author, and the latter to the same substances after annealing, so that by a comparison of the two tables, the effects of the permanent strain resulting from wire-drawing may be seen. These effects are in some instances of the same nature for the nickel-iron alloys as for nickel and iron. Thus the density of all the specimens is diminished by

* 'Roy. Soc. Proc.,' vol. 48, pp. 1—13.